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Hydro-optical Investigations on the R/V Vitiaz

The fundamental problems for the hydro-optical investigations conducted on R/V Vitiaz are the following:

a. A study of the optical characteristics of the aquatic masses in the Pacific Ocean.

b. Investigation of the relation between optical characteristics and hydro-biological factors in diverse regions.

c. Study of the relationships between the various factors causing the attenuation of radiant energy in the sea.

d. Further elaboration and perfection of the methods for oceanic hydrophotometric measurements.

The determination of optical characteristics of water during the time of the expedition is done by direct measurements, as well as with samplings of water taken with the aid of bathometers. The merit of direct measurements is evident, but the use of instruments, connected to the vessel with a cable, is of course limited by depth. Measurement of water samples can be carried out at any depth. During the studies of R/V Vitiaz in deep oceanic depressions (Japanese, Idszu-Boninska, Tonga, Kermadek) optical characteristics were determined in depths raging up to 9,000 meters. While laboratory measurements are limited to the few levels sampled, direct determination, especially with a self-registering recorder, may be conducted in deep waters as often as is desired. This rakes it possible to detect thin layers of a high degree of turbidity, usually coinciding with scattered layers of (mineral?) density or with layers of maximum content of phytoplankton. In this manner both methods, direct and laboratory measurements, are mutually complementary, and during the studies carried on from Vitiaz were employed jointly.

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Hydro-optical measurements consist in the determination of a whole complex of physical characteristics: the spectral transparency of water, its spectral indication of light scattering, the coefficient of the diffused reflection of the ocean, the indicator of vertical attenuation, and the characteristic polarization of light during its dispersion in sea water. The horizontal samplings for laboratory measurements are selected on the basis of vertical stratification of water in varying regions.

I. Hydro-optical apparatus

a. Photoelectrical instrument for measuring transparency.

The instrument constitutes a zero-differential photometer which serves for measuring the transparency of water to white light, as well as in five narrow bands of the visible part of the spectrum. The photo elements in the instrument are antimony-caesium tubes, one of which is for reference and the other for measurements. The basic purpose of the instrument is direct measurement of transparency of the water at depths ranging up to 180-200 meters. Besides this, the construction of the instrument permits measuring the transparency in samplings of water, the volume of which is only 500 cm^3.

The device consists of an immersed and an uncovered part, connected with each other by a cable. An optical sketch of the instrument is presented in illustration I. In the immersed part is found the source of artificial light, photoelements, and are assembled the optical and part of the electrical set-up of the instrument. The part which is above the water consists of the supply equipment, the registering device, amplifier-transformer, and the control device. An electric potentiometer, potentiometer EPP-09, which has proven its worth in sea conditions during the studies, is used as a registering device.

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As a preliminary, the instrument is calibrated with the help of standardized neutral filters, and the readings on the registering device correspond with the coefficient of the passage of a layer of water 1 meter thick, that is to say with its transparency. The device assures measurements of the transparency of water with mistakes no higher than 0.01.

b. Photoelectrical underwater photometer.

The apparatus is intended to measure the illumination from natural light at ocean depths varying from 0 to 150 meters. The illumination of the surface layers is measured from above, that is to say by means of light spreading from the surface downward into the sea, and from below by means of light coming from the deeper layers to the surface of the ocean. The measurements of illumination from above are conducted in white light, as well as in three bands of the visible part of the spectrum. The light filters, placed into the device for this purpose, should be as similar as possible to standard filters, recommended for hydro-optical investigations by the International Council in Copenhagen for studies of the ocean.

The apparatus consists of an underwater section and of a registering device, connected with each other by a cable. Into the underwater part are placed five transmitters, for which are used selenium photoelements with a switching device. A potentiometer (EPP-09) is employed as the registering device.

c. Spectral hydro-nephelometer.

The device is in the form of a visual photometer, which is intended to measure in the vessel's laboratory the characteristic curves of the scattering of light in water, its spectral transparency, and the degree of polarization of light in the water. The principle of the instrument's action is based on a comparison of the brightness of the light transmitted

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or scattered by water with the previously known brightness of a standardized plate of milky-colored glass. A basic design of the apparatus is presented on illustration II. The measurement of brightness of the scattered light is assured at any angle ranging from 0.5° to 144°. Besides this, the possibility of measuring light, scattered at an angle of 180° to the falling ray, is foreseen. Measurements of transparency and of the scattering of light can be conducted in white light, as well as in six narrow bands of the visible part of the spectrum.

d. Towable transparency meter.

In order to make possible the continual measurement of the transparency of the water from the surface layer during the movement of the ship, a device for measuring transparency was constructed which was capable of being towed - an objective projector in which the light flow from the source of artificial lighting is received by a cadmium photoresistor, after the passage of a layer of water 1 meter thick. The signal from the photoresistor is transmitted by cable to the registering device, a self-registering potentiometer PS-1.

II. Some results.

Curves of the vertical distribution of transparency were obtained. A few graphs are presented on illustration III as an example. On the vertical axis depths are indicated in meters, and for the horizontal axis the attenuation coefficient ε in reciprocal meters. Station 4096 relates to subtropical waters, station 4070 to the aquatic masses of the Northern Pacific current, and station 4138 to sub-arctic waters. The correlation is noted between the largest gradients of transparency of water with layers in which a sudden change has occured in temperature, determined with the aid of an electric bathythermograph. The curves of temperatures are plotted on these

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graphs with dotted lines. Strata with sharp changes in transparency are correlated with a stratum in which a sudden change in temperature has occurred. Sections of the vertical distribution of transparency were constructed. The section on the meridian 176° West longitude is presented on illustration IV. Quite characteristic appears to be the zone of a high degree of transparency between 41° and 45° Northern latitutde, coinciding with the aquatic mass of the North Pacific current. The iso lines of transparency determines sufficiently clearly the borders of the aquatic masses.

Measurements of underwater illumination have permitted to form a better idea about the nature of the attenuation of the sources of natural radiation with depth and to determine important optical characteristics: the index of vertical attenuation and the coefficient of the diffused reflection of the sea.

A number of characteristic curves of light diffusion have been obtained, characterizing the conditions governing the diffusion of light in various aquatic masses. Indexes of scattering were computed by measurements at different angles θ according to the indications on the diffusion meter β.

The comparison of the curves of vertical distribution of turbidity (ε) and of the curves of the relation between photosynthesis and the concentration of photoplankton (F) showed their almost complete identity (illustration V). The same similarity was found to exist between turbidity (ε) and the contents of nitrates (N), the distribution of which is connected with phytoplankton (illustration VI).

The studies on Vitiaz have offered an opportunity to reveal some deficiencies in the measuring apparatus, which will be corrected or modified in the construction of new instruments.

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Illustration I. An optical sketch of the photoelectrical transparency-meter.

1 - source of artificial light
2 - mirror
3, 7, 9, 10, 12, 14 - lenses
4, 8, 11, 13 - aperatures
5 - heat absorbing glass
6 - comparison photoelement
15 - measuring photoelement
16 - light filters

Illustration II. Theoretical sketch of a hydro-nephelometer SCI-57.

As seen from the side

As seen from above

1 - water sample (?)
2 - objective of the lighter
3 - aperture
4 - lens
5 - source of the light
6 - graduated plate
7 - objective of the photometer
8 - mirror in form of knife (knife-edge mirror)
9 - lenses
10 - light filters
11 - exit pupil of the orifice
12, 13, 14, 17 - milky glass
15 - photometer lamp
16 - reading drum - calibrated
18 - aperture
19, 20, 21 - calibrating lightfilters
22 - milky glass
23 - analyzer
24 - polarizer
25 - spherical mirror
26 - storage battery
27 - rheostat
28 - amperemeter
29 - voltmeter
30 - switch

Illustration III. Curves of the vertical distribution of turbidity and temperature

a) station 4070 / aquatic mass of the Northern Pacific current

b) station 4096 / sub-tropical waters

c) station 4138 / sub-arctic waters

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Illustration IV. Distribution of water transparency of a section on the meridian 176° west longitude.

Illustration V. Vertical distribution of turbidity (index of weakening in reciprocal meters) and photoplankton in percentages of content in the uppermost layer at station 4066 sub-arctical waters.

Illustration VI. Vertical distribution, of turbididty (index of the weakening in reciprocal meters) and contents of nitrites in micrograms per liter at stations 4120 sub-arctical waters and 4096 sub-tropical waters.

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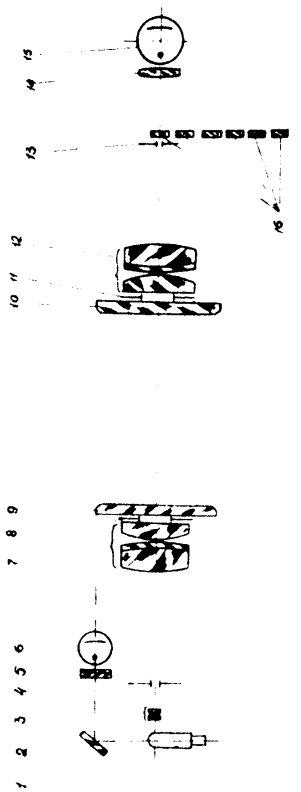

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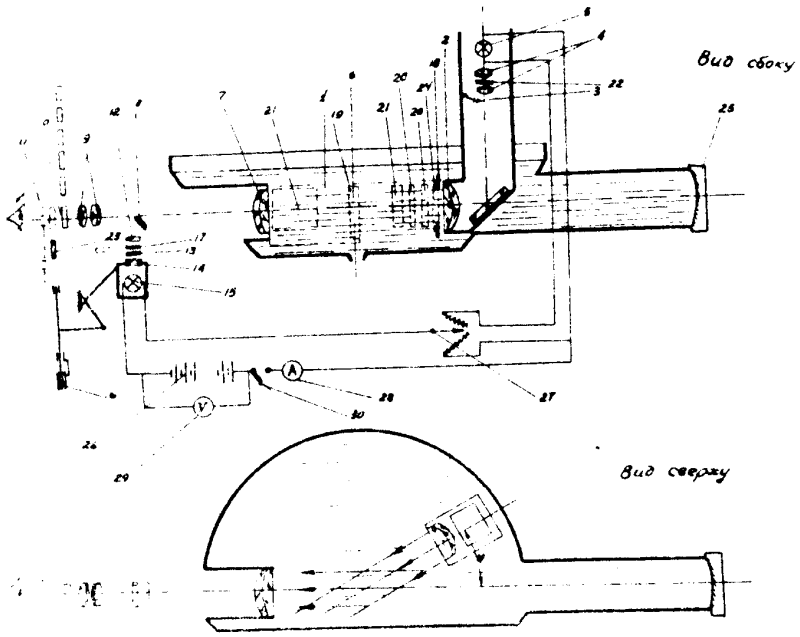

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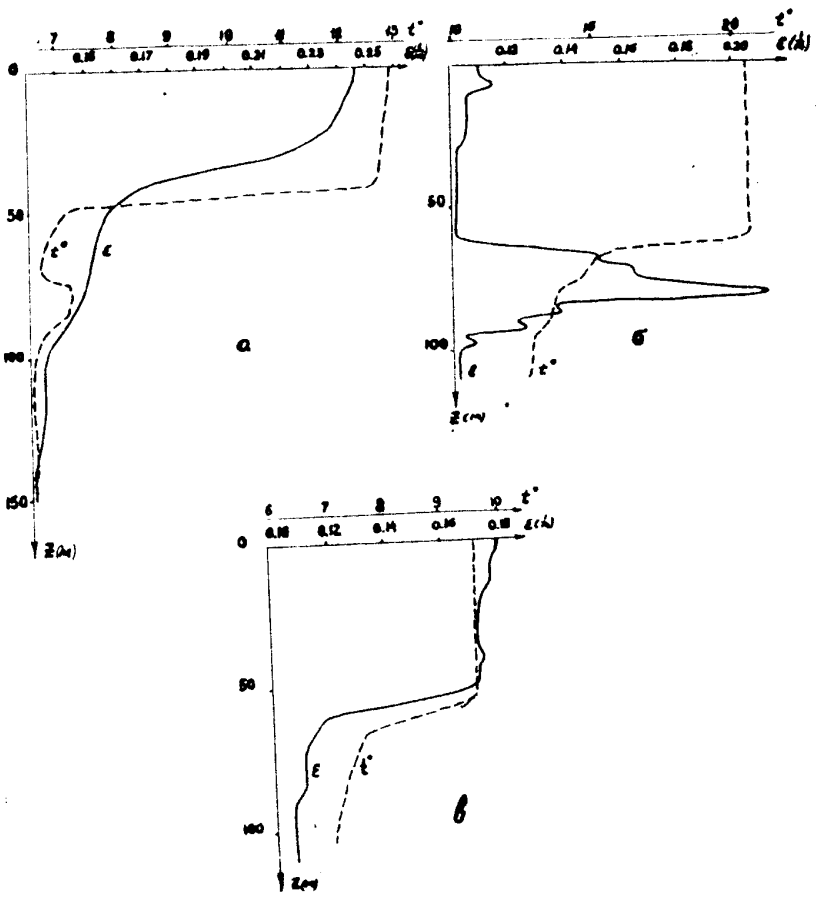

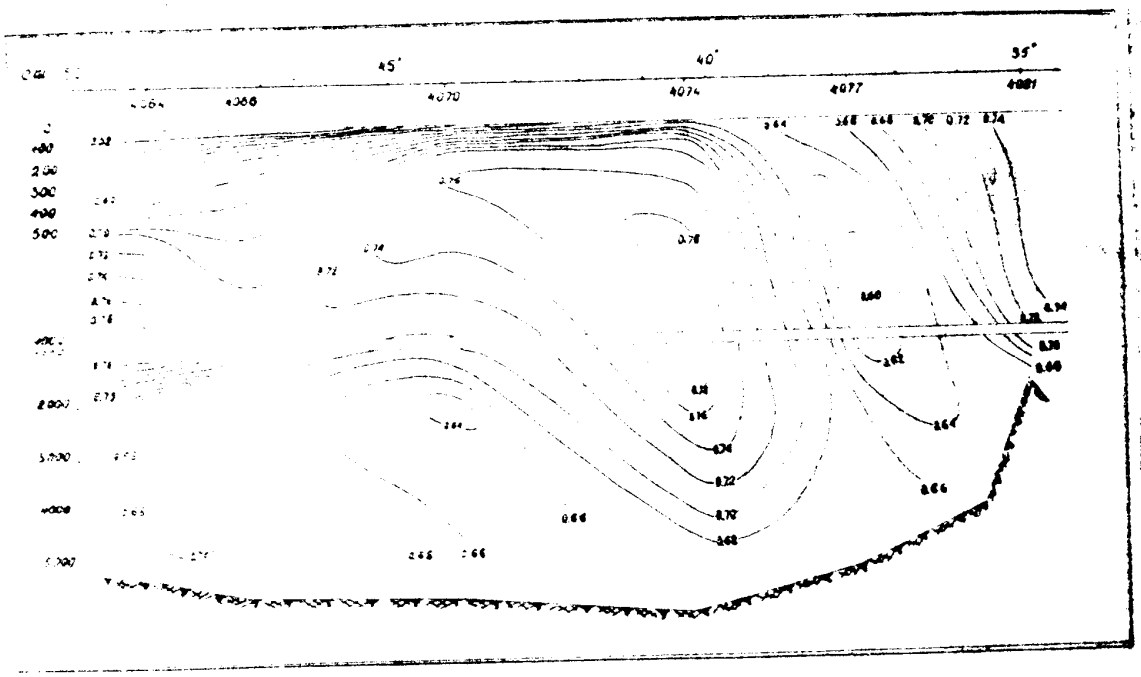

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Fig. 5

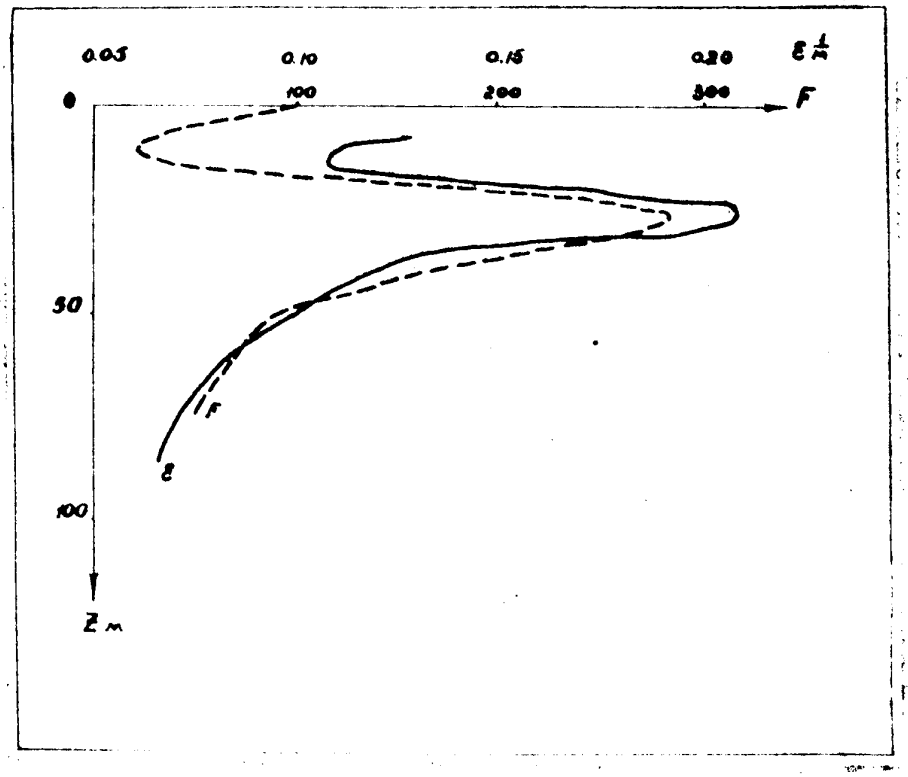
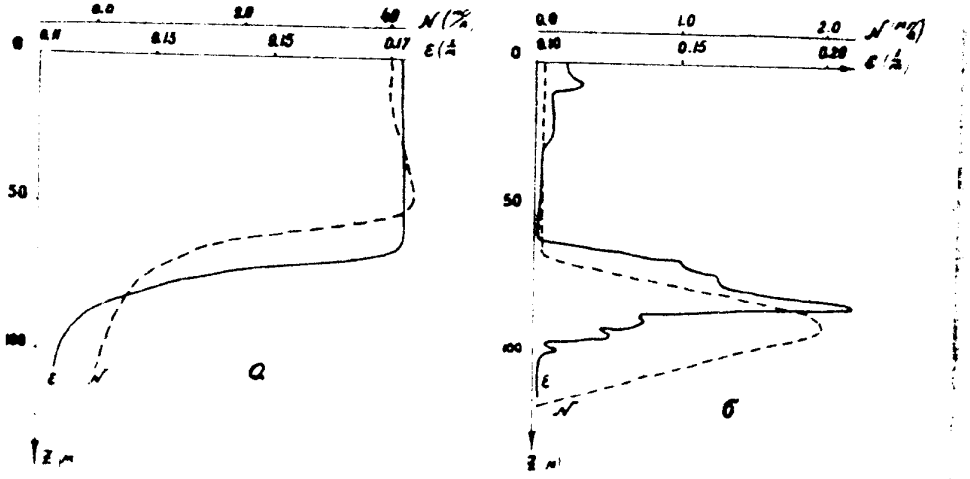


Fig. 6



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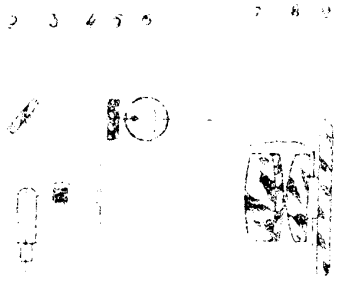

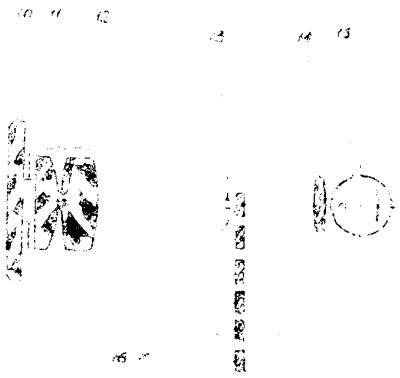

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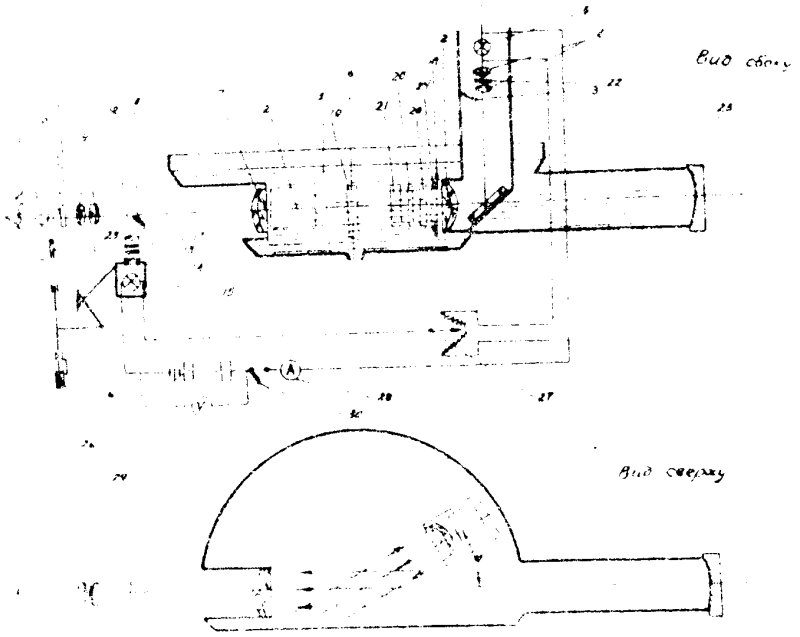

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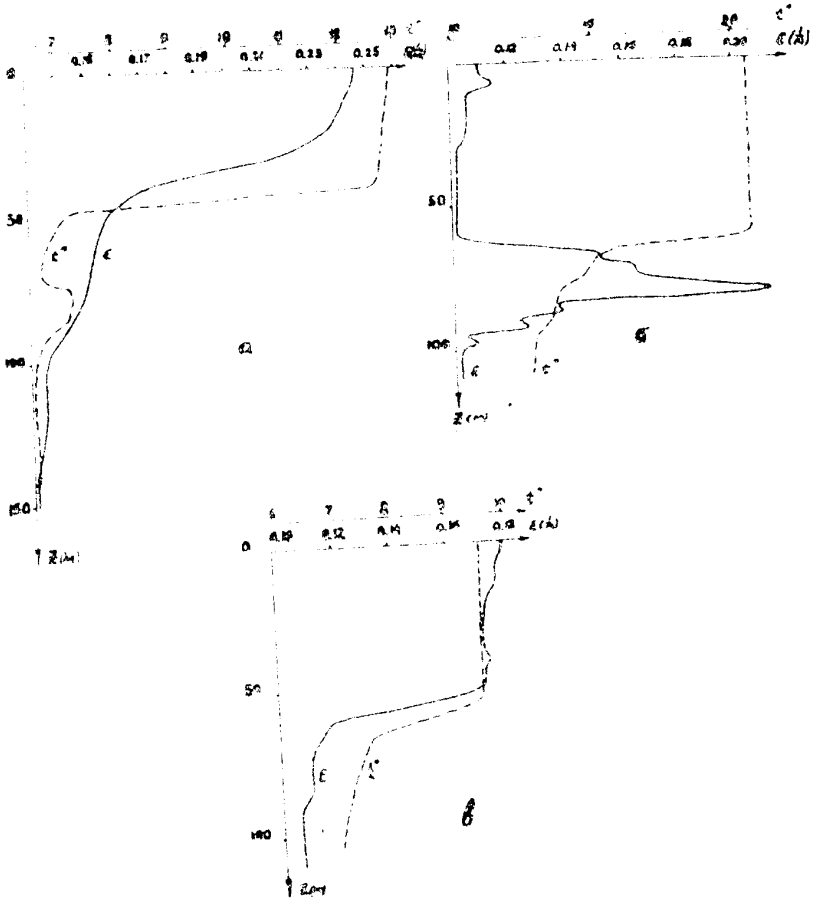

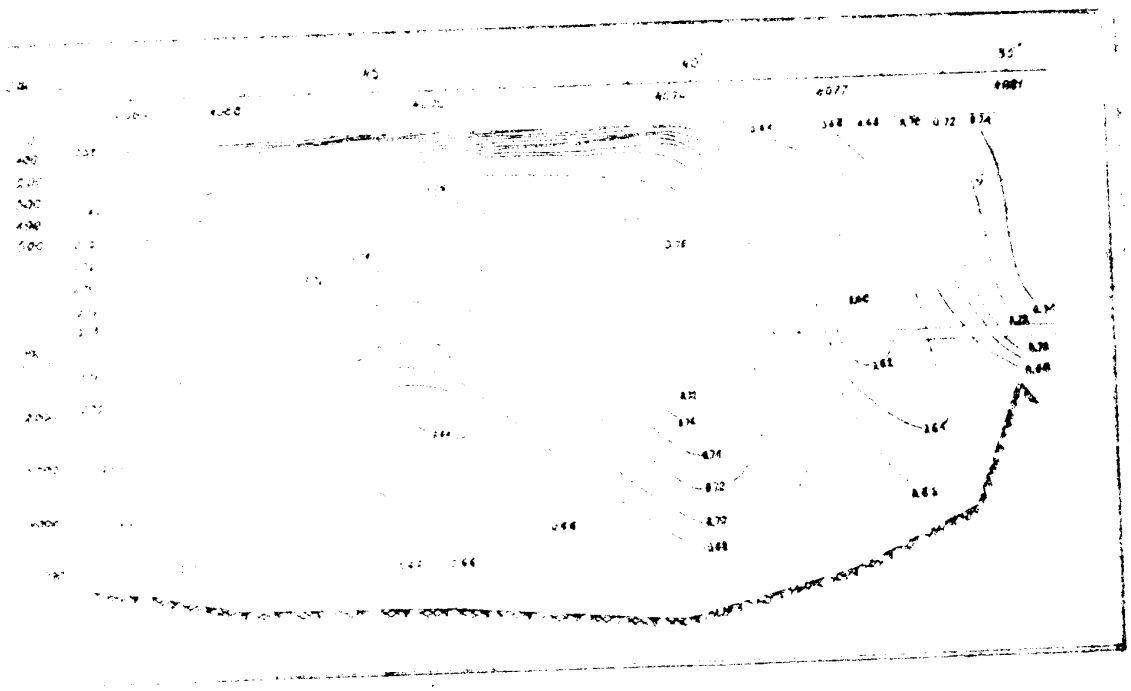

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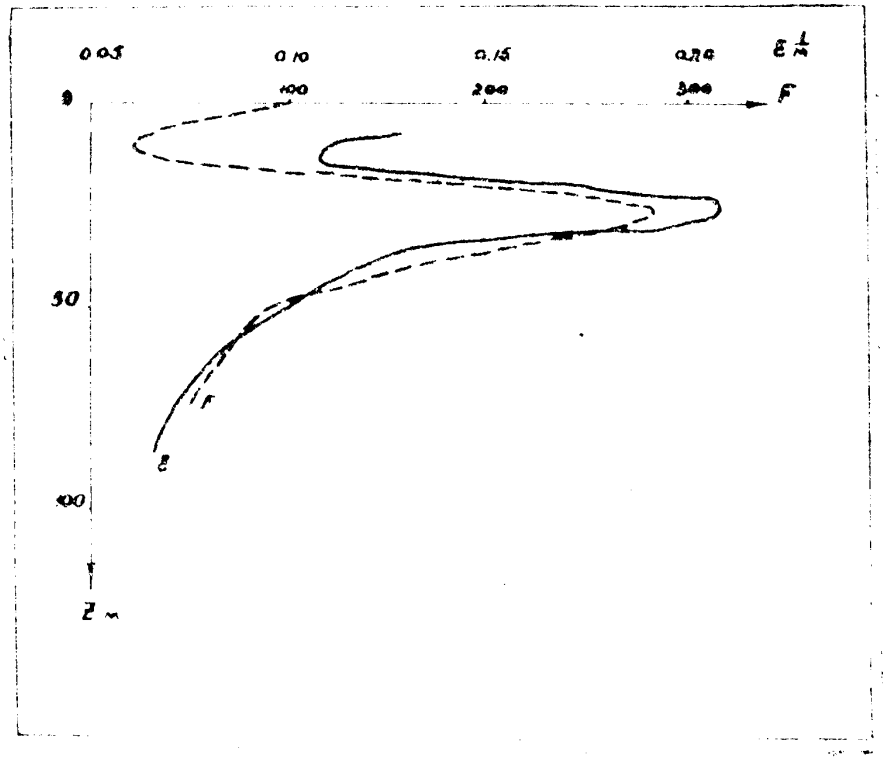

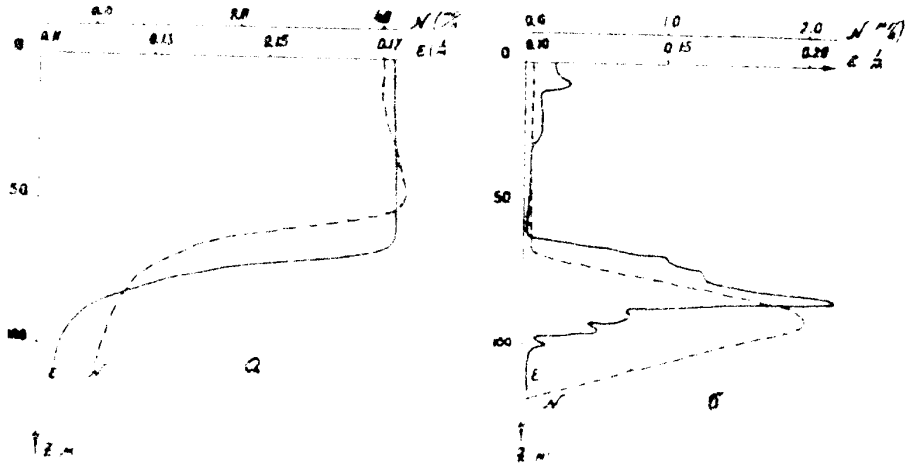

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